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Requirements Elicitation with Extended Goal Graph

Noriyuki Kushiro*, Takuro Shimizu, Tatsuya Ehira

Kyushu Isntitute of Technology, 680-4 Kawazu, Iizuka, Fukuoka 820-8502, Japan

Abstract

Requirements for a system are often discovered during negotiation process for conflicts among stakeholders, rather than at the time when stakeholders are thinking about their own requirements uncritically in a requirements meeting. Conflicts could be utilized as a driving force to discover significant functional and/or non-functional requirements for the system, by handling conflicts in the requirements meeting appropriately. In this paper, we propose a support tool for discovering conflicts, called as an extended goal graph. We implemented a prototype of the tool and constructed an environment for analyzing requirements meeting. The prototype and the environment were applied to a requirements meeting on improvement of selling area in drugstore. Issues and solutions for practical use of the tool are discussed on the results of feasibility test.

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Keywords: Support tool for requirements meeting; Extended goal graph, Environment for analyzing progress of requirements meeting

1. Introduction

There is a growing interest to define system specifications through a group work between system designers and stakeholders as complexities of the system increase. However, the result of the group work fell short of our expectation. Over 90% of time of the meeting is useless [1], and 80% of time is wasted to solve conflicts derived from differences of premises that each stakeholder is standing [2]. Requirements are often discovered during negotiation process empirically, at the time when they are thinking over premise or backgrounds behind other stakeholders' requirements, rather than at the time when stakeholders are thinking about their own requirements uncritically [3]. When we can manage conflicts in the requirements meeting appropriately, the conflicts are utilized as a driving force to discover significant functional and non-functional requirements, which are difficult to find out.

* Noriyuki Kushiro: kushiro@mx1.ttcn.ne.jp

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In this paper, we propose a support tool for discovering conflicts, called as an extended goal graph (EGG). We implemented a prototype of the EGG and constructed an environment for analyzing requirements meeting with the EGG. The prototype and environment were applied to a requirements meeting improvement of selling area in a drugstore. Issues for practical use of the tool ant their solutions are discussed on the results of the feasibility study.

The rest of the paper is organized as follows: in section 2, overview of the EGG and the environment for requirements meetings with the EGG are explained. in section 3, results of requirements elicitation with the EGG are described. in section 4, issues of requirements meeting with the prototype of the EGG and solutions for the issues are discussed. the section 5 concludes the paper.

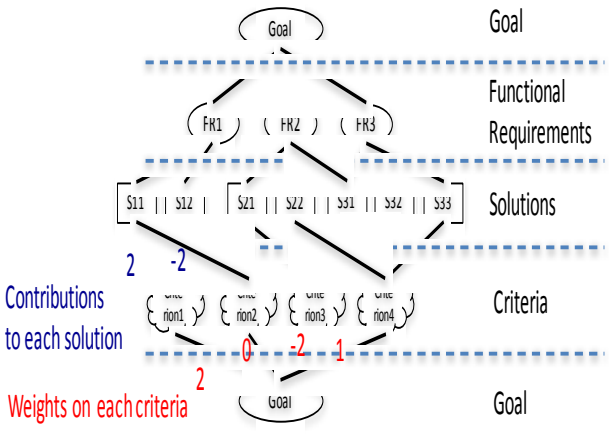
2. Overview of the EGG and environment for require meeting with the EGG

2.1. Concept of the EGG

A major factor that the result of the requirements meeting fell short of our expectation, is that stakeholders are difficult to grasp a whole picture of requirements for the target system during the meeting. A number of approaches for drawing the whole picture of requirements have been considered in recent years. Goal graph [4] and NFR [5] spread in the system engineering domain. QFD [6] is frequently used in the quality engineering domain. These methods are commonly based on the goal-oriented approach that structuring requirements with goals, requirements (functional and non-functional), solutions and relations among them. However, these methods could not help both engineers and stakeholders to detect conflicts during the requirements meeting. In the NFR, conflicts are depicted with "+" and "-" attached to the link between goals, requirements and solutions. In the QFD, conflicts are noted with "x" between functional requirements and between non-functional requirements respectively. Both of notations are useful for describing conflicts conclusively as a result of requirement analysis. Recently, the methods to help engineers detect conflicts among stakeholders on empirically approach are proposed [7,8]. [7] is based on a statistical analysis of empirical data collected from the stakeholders. [8] uses a scoring technique for understanding differences of each stakeholder's requirements intuitively.

A support tool for discovering conflicts is indispensable for applying the goal-oriented approaches to a requirements meeting. We propose the extended goal graph (EGG) [9] as the support tool for discovering conflicts and drawing the whole picture of requirements during the requirements meeting. The concept of the EGG is described as follows (Fig.1):

- Express interdependent structure of the whole picture of requirements as a symmetrical tree structure
- Manage both functional and non-functional requirements (criteria) concurrently
- Support to identify conflicts among requirements, solutions, criteria and stakeholders
- Support to find out implicit solutions and criteria for the target system



Terms in the EGG are defined as the followings: Functional requirements are defined functions that the system shall provide to the stakeholders. Criteria are defined quality requirements and constraints for realizing solutions, e.g. performance, reliability and costs.

The EGG illustrates structure of the requirements by placing "Goal -- Functional Requirements (FR) -- Solutions(S)" and "Goal -- Criteria(C) -- Solutions" in the liner symmetry for managing both functional and non-functional requirements concurrently. The criteria are weighted by every stakeholder on each functional requirement, and the solutions are also evaluated with the score from -2 to +2. As a result, each solution is estimated with the product of (the weight) and (the contribution).

Fig. 1. Extended Goal Graph

The results of estimations are propagated to functional requirements via links. The stakeholders are able to grasp how solutions satisfy functional requirements. By focusing on some functional requirements, the EGG emphasizes all solutions and criteria linked to the functional requirements for identifying conflicts. The EGG also provides several supplementary graphs and tables to support for finding out implicit solutions and criteria for the target system. The prototype of the EGG was implemented on Microsoft Excel and VBA [9].

2.2. Environment for requirement meeting with the EGG

An environment for supporting requirement meetings with the EGG was developed [10]. The environment consists of vison sensors and projectors (Fig.2 left). All attendees (stakeholders) stand around workspace and conduct requirements meeting according to facilitator's instructions (Fig.2 center). The environment provides functions for supporting the group work during the meeting and for analyzing the results of the meeting (Fig.2 right).

Fig. 2. *Environment for requirement meeting with the EGG*

3. Require elicitation meeting with the EGG

To confirm feasibility of the EGG, we applied the prototype of the EGG to a requirements meeting, in which improvement plans for selling area in a drugstore were discussed among a store manager, a sales clerk and customers.

3.1. Basic setup for the requirement meeting with the EGG

Table 1 shows the basic setups for the requirement meeting.

Table 1. Basic setups for the requirement meeting

Item	Contents
Theme of requirement meeting	Solutions for improving selling area in a drugstore
Attendees of the examination	Shop manager (1), Sales clerk (1), Customer (2), Facilitator(1)
Total required time for the meeting	270minutes
Experiment environment	The meeting was conducted under the environment for the requirement meeting with the EGG, the environment monitored and recorded the follows: 1. Verbal data a) Communications among stakeholders b) Time series data for which stakeholders spoke 2. Non-verbal data a) Video image for the meeting

	b) Time series data for pointing sticky notes by stakeholders c) Time series data for sticky notes adding and removing on the workspace

3.2. Process of requirement meeting on the EGG

The experiment was carried out along the process shown in Table 2.

Table 2. Process of requirements meeting on the EGG

Phase	Step	Actions
1. Extract problem and create solutions through group work (Time required: 180minutes)	1	**Preparation**: Customers shopped some items at the drugstore with wearable camera for understanding problems in selling area
	2	**Extract problems**: The environment projects video for customers' shopping on the workspace, and each stakeholder extracts problems for shopping with the brainstorming method [11]
	3	**Clustering problems**: Stakeholders arrange problems with the affinity map [11] on the workspace
	4	**Create ideas**: Stakeholders create ideas for solving problems with the brainstorming method
	5	**Define goal and criteria** : Stakeholders define criteria to satisfy goal through group work
2. Facilitator input problems, solutions and criteria into the EGG (Time required: 60minutes)		
3. Brush up requirements, solutions, and criteria, and define goal of the target system through group work (Time required: 30minutes)	6	**Estimate weights and contributions**: Each stakeholder estimates weights for criteria and contributions for solutions on the EGG
	7	**Discover conflicts**: Stakeholders discover conflicts between criteria, and between solutions, through the group work
	8	**Negotiations**: Stakeholders discuss solutions and criteria to solve conflicts which were discovered in the previous step
	9	**Brush up the EGG**: Stakeholders redefine goal, requirements, solutions and criteria based on the discussion among stakeholders

3.3. Results of examination

(1) Preparation and Extract problems (Step 1 and 2)

2 Customers shopped medicines or commodities at the drugstore to grasp problems in selling area before attending the requirements meeting (Fig.3 left). The video for their shopping was projected on the workspace by the meeting environment. Stakeholders (shop manager, shop clerk, and 2 customers) extracted problems in selling area with the brainstorming (Fig.3 right). As the results, 38 problems were elicited.

Fig. 3. *Preparation and Extract problems (left: shopping in the drugstore, right: brain storming with stakeholders)*

(2) Clustering problem and Create ideas (Step 3 and 4)

Problems, extracted through the previous steps, were clustered with the affinity map supported by the meeting environment (Fig.4 left). Stakeholders choose 3 significant problems by voting (Fig.4 right) and defined them as the following functional requirements (**FR1**: Support customers to receive medicine and commodity service separately, **FR2**: Support customers to find goods in the shop, **FR3**: Support staff to work effectively).

Continuously, the idea meeting for extracting solutions were carried out with the brainstorming. Thus, 35 ideas for satisfying the above functional requirements were extracted.

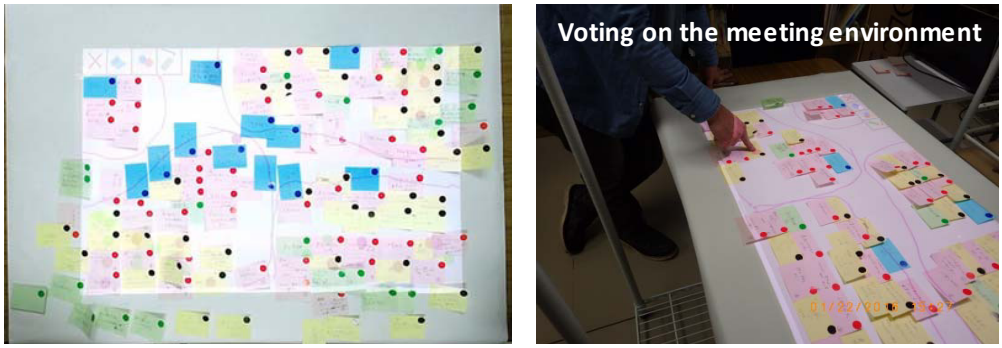


Fig. 4. *Clustering problems and create ideas (left: clustering problems with affinity map, right: voting on the meeting environment)*

(3) Define goal and criteria (Step5)

Criteria for adopting ideas were extracted and the goal for improving selling area was defined through group work. One goal: Support customers who have different purposes and make staff's work effectively**,** and 8 criteria shown in Table 3, were defined.

Table 3. Criteria for adopting solutions to satisfy the goal

Criteria	
C1	Customers can swiftly consult a pharmacist.
C2	Customers can clearly distinguish between a commodity section and a medicine section.
C3	Shop manager can save the initial cost.
C4	Customers can easily find goods.
C5	Customers are easily guided to commodity display shelf.
C6	Staff can use their time effectively.
C7	Customer’s privacy is protected.
C8	Shop manager can save the running cost

(4) Estimate weights and contributions and Discover conflicts (Step 6 and 7)

Criteria were weighted with the score from -2 (not significant) to +2 (significant) by every stakeholder separately. Solutions were also evaluated on contributions to satisfy criteria with the score from -2 (solution hazards criterion) to +2 (solution satisfies criterion). Each solution was prioritized with the product of the weight and the contribution. After estimating the weights and contributions by the stakeholders, the EGG draw the whole picture of the requirements (Fig.5). The values propagated to each functional requirement along the the link between solutions and the functional requirement in the EGG. As the results, each functional requirement was estimated its accomplishment for the goal with the values.

The EGG supports to discover the following three kinds of conflicts [9]:

Case 1: conflicts among criteria, which originate from a technical tradeoff or a restriction between criteria

Case 2: conflicts among stakeholders' requirements, which originate from differences in weight for criteria

Case 3: hidden conflicts among criteria causes by the connections with functional requirements

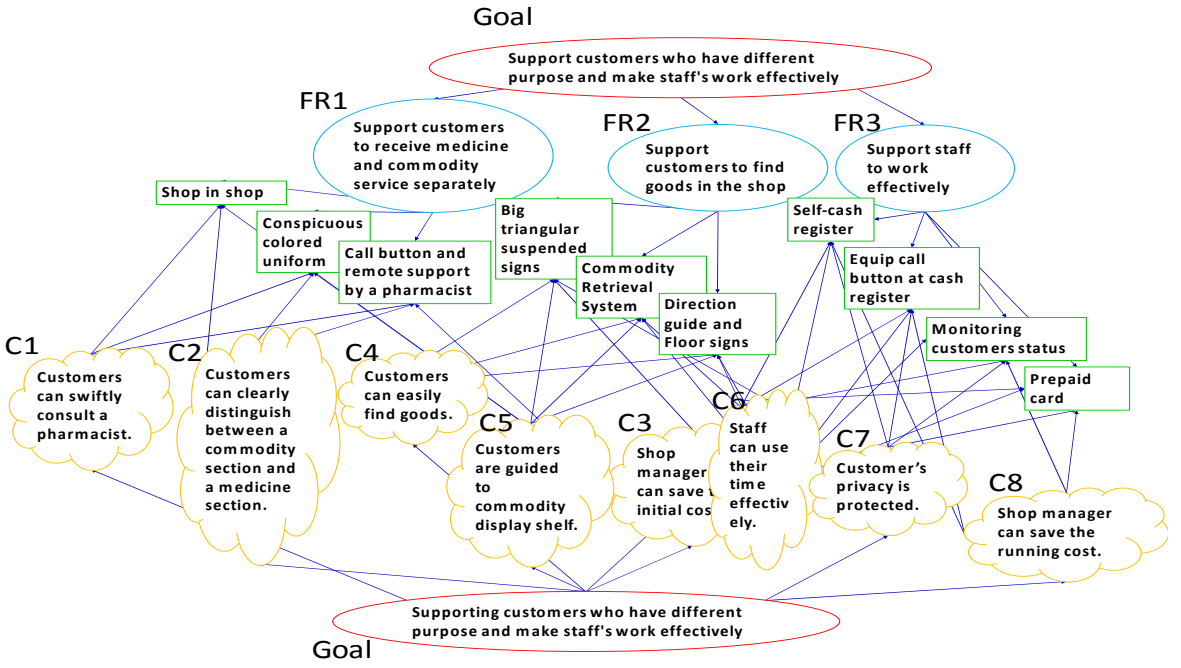


Fig. 5. *Extended Goal Graph(EGG) for improvement of selling area in the drugstore*

(5) Discuss solutions and criteria for solving conflicts and Brush up the EGG (Step 8 and 9)

The EGG succeeded in discovering conflicts in Case 1 and 2 (Table 4). On the other hand, there was no conflict in Case 3, because of the topology of the EGG shown in Fig.5. In this case, every solution connected to the independent functional requirement.

Table 4. Number of conflicts discovered by the EGG

Case	Number of conflicts
Case 1	30
Case 2	3
Case 3	0

Examples of conflicts in Case 1 and 2 are shown in Fig. 5. The criterion C1: "Customers can swiftly consult a pharmacist" conflicted with the criterion C3: "Shop manager can save the initial cost" for realizing the solution "Call button and remote support by a pharmacist" in Fig.5 left. As for the conflict in Case 1, the facilitator had better to promote the stakeholders to seek alternative solutions for satisfying both criterion simultaneously, or to relax weights of either criterion through negotiation.

The criterion C1: "Customers can swiftly consult a pharmacist" was weighted in different by the stakeholders in Fig.5 right. The shop manager and the 2 customers highly weighed C1, on the other hand, the shop clerk disliked C1 because the shop clerk was afraid to increase dissatisfaction of customers. Through interviewing the shop clerk on the EGG, we got implicit premises that there were many customers to ask

assistance from the pharmacist at the same time, and customer's long waiting time for the pharmacist increased dissatisfaction of customers in fact. As for the conflict in Case 2, the facilitator had better to ask stakeholders to search solutions for satisfying stakeholders' criteria, or promote to reconcile differences of weights among stakeholders through negotiation.

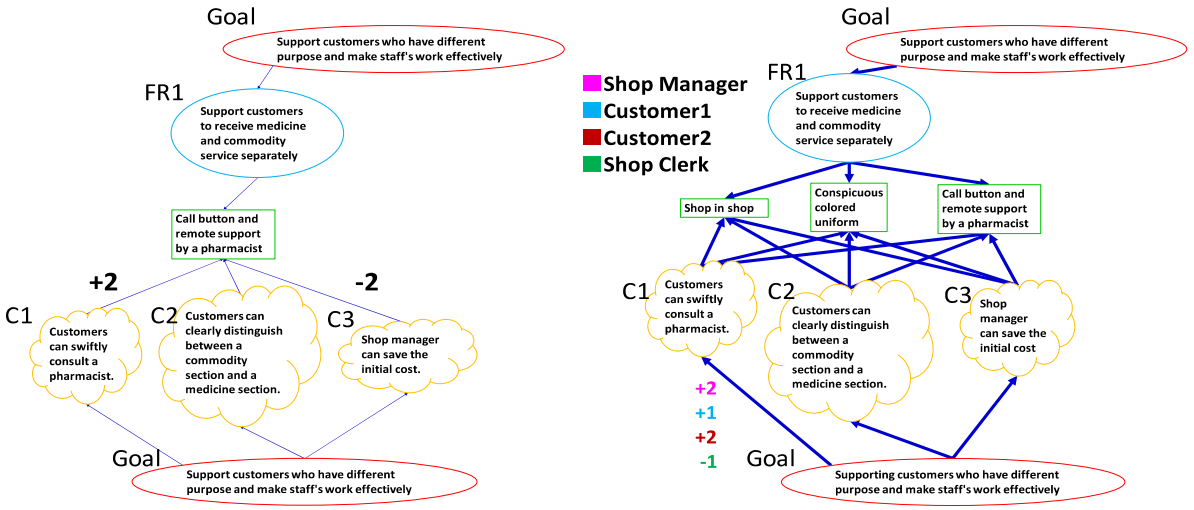


Fig. 5. *Examples of conflicts discovered in the EGG (left: conflict in Case 1, right: conflict in Case 2)*

The scoring technique (weights and contributions) is not expected to promote decision making, but to activate negotiation among stakeholders and elicitation of premises and restrictions behind the stakeholders' requirements. An example of negotiation on the EGG is shown in Fig.6 and Fig.7. S1 "Shop in shop" was selected unanimously as the solution for FR1 "Support customers to receive medicine and commodity service separately" as the results of the scoring (Fig.6).

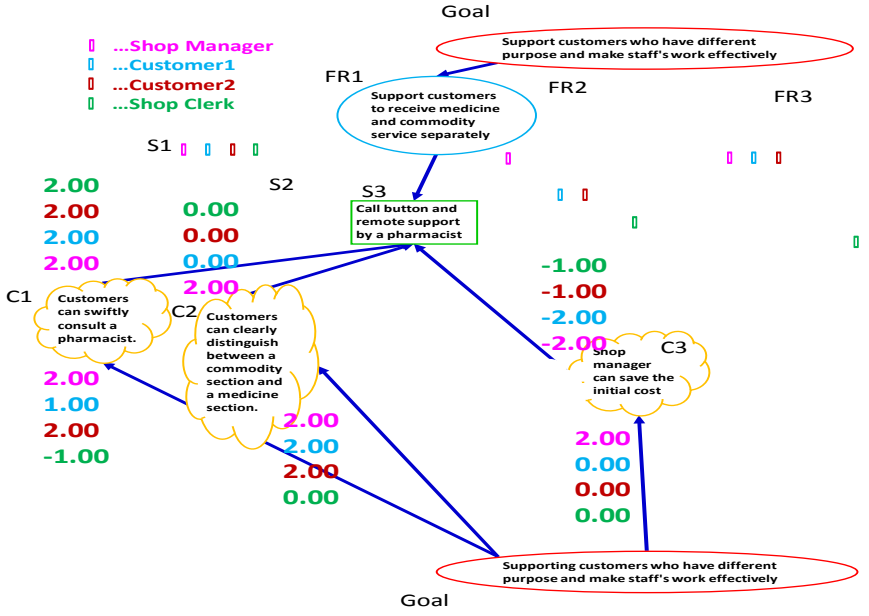


Fig. 6. *Example of negotiation on the EGG*

However, the customer-2 was attracted to the S3 personally. Therefore, the customer-2 began to check the reason why the S3 was not highly estimated on the EGG during the meeting. As the results, all the stakeholders recognized the fact that the shop manger highly estimated C1 and C2, however, C3 heavily hindered the S3 (Fig.7).

The stakeholders began to negotiate new solutions to satisfy C3 and new criteria to beat C3 (Fig.7). Through negotiation, the new criterion "Shop manager differentiate the shop from competitors" was discovered. The shop manager accepted the new criterion. S3 was revived as an alternative solution for FR 1.

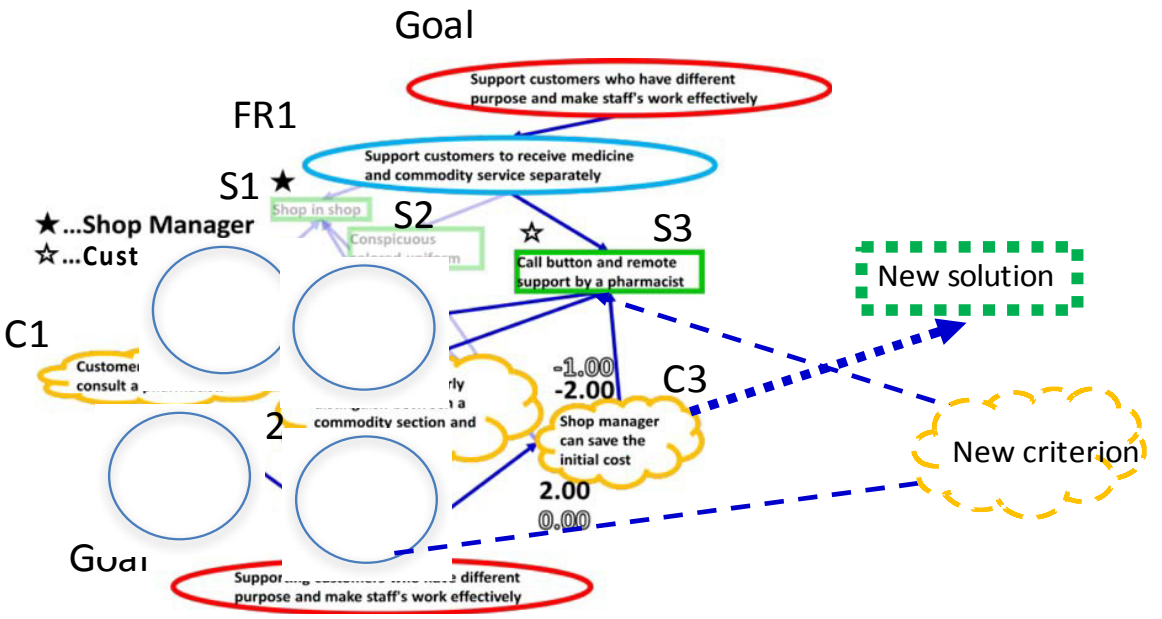


Fig. 7. *Discover new criterion through negotiation on the EGG*

4. Issues of the EGG as supporting tool for requirement elicitation meeting and Solutions

We confirmed that the EGG supports to discover conflicts and contributes to promote discussion for seeking new solutions and criteria through the experiment. Furthermore, the EGG was succeeded in extracting premises and restrictions which stakeholders hold implicitly behind requirements. However, there are some issues in the prototype of the EGG for practical use in the requirements meeting as follows:

(1) Difficulty of expression for functional requirements and criteria

All the attendee of the requirements meeting felt difficulty for how to express functional requirements and criteria in the EGG. To relax the difficulty, we define the following guideline for expression of functional requirements and criteria:

- Expression of functional requirement: functional requirements should be described as a sentence by starting "Function to ", e.g. "(Function to) support customers to receive medicine and commodity service separately"
- Expression of criterion: criterion should be described as a sentence: (subject) + (verb) + (object), e.g. "Shop manager can save the initial cost". Because, it is very important to express that who is a beneficiary of the criteria and what is a metric to estimate achievement of the criterion.

(2) Difficulty of evaluation of weights and contribution with the value

We adopted the absolute scale method in the EGG instead of one-pair appraisal method for reducing time for scoring, However, the absolute scale method often fails to estimate the value appropriately. For

example, the shop manager evaluated all the criteria as very significant (+2) without priorities (Fig.6). Because, all the criteria were seemed to be significant and more from a view point of the shop manager.

The prototype adopted separated tables as an input method for every weight and contribution. The input method wasted time for its redundancy. Sophisticated method is necessary for practical use of the tool. For example, GUIs like equalizer is under estimation for the input method. By using GUIs like equalizer, we expect that the estimation of weights and contributions becomes relative, intuitive and effective.

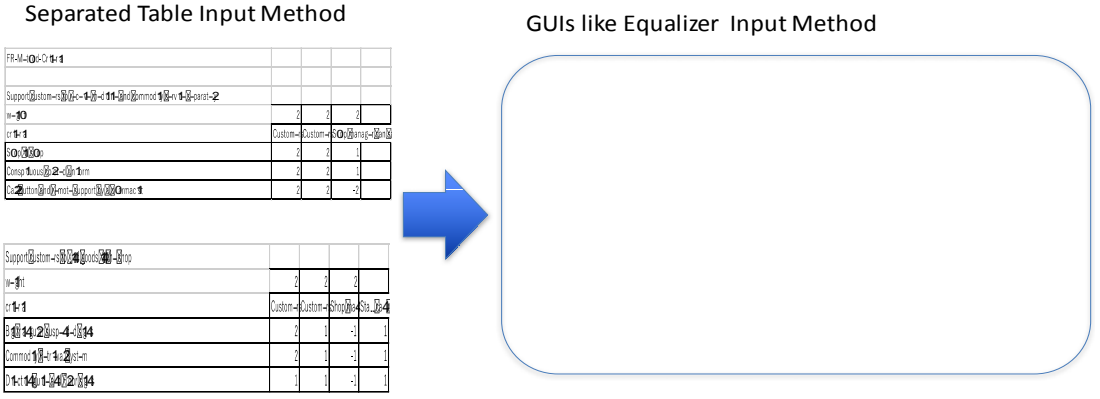


Fig. 8. *Input method for weights and contribution for future version of the EGG*

(3) Lack of immediacy of discovering conflicts

There is difficulty to discover conflicts intuitively in the prototype, because it requires to read the numerical value attached to each link. Visualization for conflicts on the EGG, and/or automatic detection of conflicts are required for practical use.

(4) Necessity to support precise decision making on metrics

An ambiguity remains at estimation of weights and contributions. Because, we didn't clarify metrics for every criterion in the prototype. There is a need to expand the EGG as a consistent tool for requirement analysis and design. For satisfying the need, we plan to expand the EGG to have two laminar structure: requirements plane and design plan. These two layers are connected with metrics (Fig.9). The metrics is calculated its value on data and algorithm in the design plane (Fig.9). The metrics propagates to each criterion via link between two planes. By this expansion of the EGG. we aim to improve quality of negotiation during the meeting, and to realize traceability between requirement analysis and design.

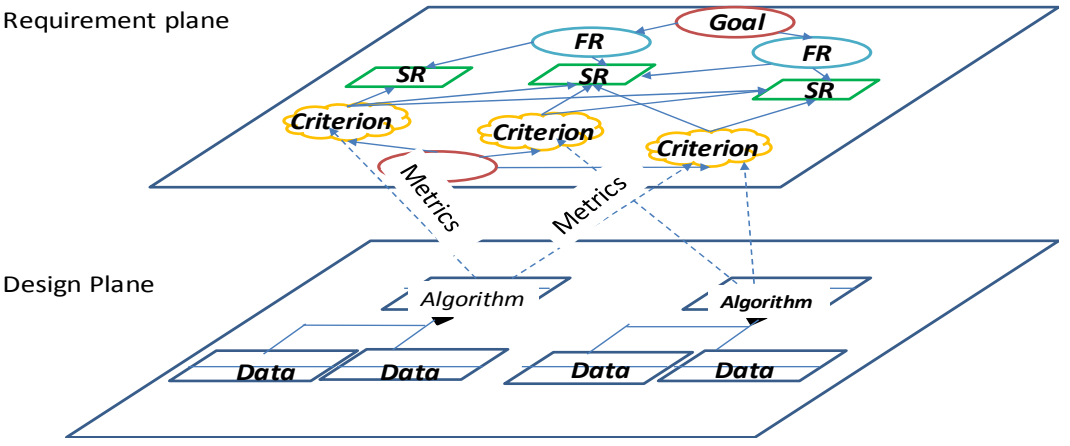


Fig. 9. *Future plan of the EGG expansion*

5. Conclusion

Requirements for a system are often discovered during negotiation process for conflicts among stakeholders, rather than at the time when stakeholders are thinking about their own requirements uncritically. By handling conflicts in the requirements meeting appropriately, conflicts could be utilized as a driving force to discover significant functional and/or non-functional requirements.

We propose a support tool for discovering conflicts during the meeting, called as the EGG. We implemented a prototype of the tool and constructed an environment for analyzing quality of requirements meeting. To confirm feasibility of the EGG, we applied the prototype of the EGG to the requirements meeting, in which improvement plans for selling area in a drugstore were discussed among a store manager, a sales clerk and customers.

Through the experiment, we confirmed that the EGG supports to discover conflicts and contributes to promote discussion for seeking new solutions and criteria. Furthermore, the EGG was succeeded in extracting premises and restrictions which stakeholders hold implicitly behind requirements. However, the following 4 major issues were discovered in the experiment:

(1) Difficulty of expression for functional requirements and criteria
(2) Difficulty of evaluation of weights and contribution with the value
(3) Lack of immediacy of discovering conflicts
(4) Necessity to support precise decision making on metrics

We already have started upgrading the EGG to solve the above issues and will become the EGG as a practical tool for the requirement meeting in the near future.

Acknowledgements

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